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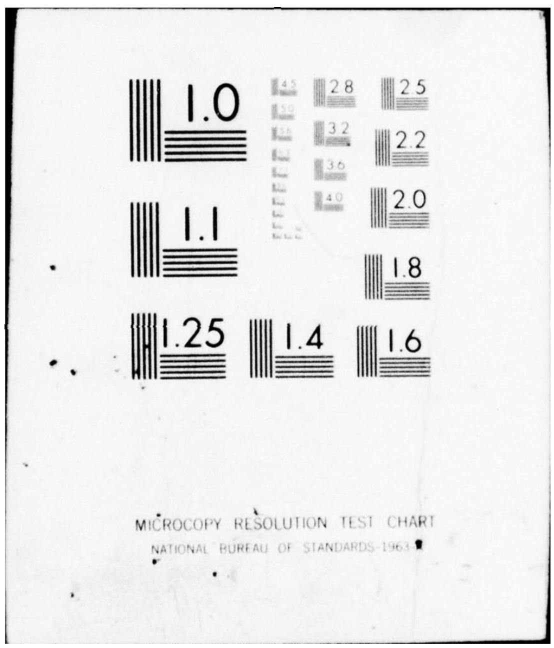
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DEPARTMENT OF THE ARMY
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AVIATION SYSTEMS SUBGROUP REPORT

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FOREWORD

The Army Scientific Advisory Panel (ASAP) conducted its Summer Study '76 at the Armed Forces Staff College, Norfolk, Virginia, during the period 19-30 July 1976. The Panel addressed the theme of Future Systems through the six subgroups of Armament, Aviation, Electronic, Missile, Mobility, and Soldier Support Systems.

Thirty-six individuals from the ASAP and sixty representatives from the Department of the Army General Staff and major commands participated in the two week study. The Specific tasks of the participants were (1) to examine the compatibility of two documents - the Science and Technology Objectives Guide (STOG), which delineates desired operational capabilities in various categories, and the systems development plans prepared by the Army Laboratories - and (2) to determine if the laboratory programs contained the appropriate technology efforts to achieve the desired systems capabilities. It was requested that in the process that technical efforts non-supportive of the STOG or of marginal value be identified. Three ancillary tasks were subsequently added by which subgroup chairmen were requested to: (1) assist US Army Training and Doctrine Command (TRADOC) representatives to acquire and interpret significant material for use in input for STOG-78; (2) identify and describe ideas to be pursued by TRADOC in cooperation with U. S. Army Materiel Development and Readiness Command (DARCOM) using Concept Development and Validation (CDV) funds; and (3) suggest new initiatives appropriate for Army R&D.

The Summary Study participants arrived at a general concensus in their respective reports regarding the STOG. First of all, they felt that it is a good vehicle for providing guidance to the laboratories as well as a mechanism to conduct a dialogue between developer and user. The laboratory programs are generally responsive to the STOG and have improved in relevance to requirements over that of previous years. Most technology base efforts relate to some Science and Technology Objective (STO) to varying degrees. The level of detail of the STOG appears appropriate; however, the STOs should not constrain good laboratory efforts in high pay-off areas. The participants heartily endorsed the concept of having the STOG replace a variety of other guidance documents and serve as a guidance directory.

The STOG can be expected to be more useful and relevant in subsequent iterations, but it should not become so institutionalized that other opportunities for providing guidance and exchanges are precluded. The document should convey the user's comments on how he fights and his perception of desired systems capabilities and not closely specified

solutions. Soldier support technology, as well as techniques for better utilization of hardware in support of Corps of Engineers missions, should be covered more adequately in the STOG. The subject of smoke as a problem area arose in all areas examined.

Lastly, the STOG should include provision for countering advanced and alternate threats and reflect a strong intelligence input. A time frame should be identified in the STOG.

The reports of the subgroups are being published as six separate documents, each with a summary of recommendations near the beginning of the volume on colored paper. The documents are on file with the Defense Documentation Center. The value of Summer Study '76 will be the extent to which the appropriate Army managers find the conclusions helpful.

AVIATION SYSTEMS SUBGROUP REPORT

A. INTRODUCTION AND SUMMARY OF RECOMMENDATIONS

The Aviation subgroup received briefings from various Laboratories and Program Managers and reviewed the Science and Technology Objectives Guide (STOG) as well as various relevant laboratory system plans.

As a result of the deliberations of the subgroup, four items were considered to be of major importance, and therefore this chapter is organized to present the discussion of each of these items separately. These four areas of significance to Army Aviation are:

a. AMRDL and its flight research simulator

b. *The RPV program*

c. Human Factors/Behavioral Sciences

d. Helicopter Weapons System Design Integration.

The most general observation by the subgroup is the need for the establishment of a "center of competence" for the purpose of Weapons System Integration. At present the competences required to make the helicopter a total weapons system as distinguished from a flying machine are different and fragmented. The burden falls on the system program manager to integrate the various *subsystems without* the benefit of the prior development work necessary for such an integration. A weapon-system integration facility at AMRDL in which all subsystems can be interconnected to uncover in the laboratory the subsystem interference and interactive effects that would otherwise be found in flight late in the development program is urgently required. The facility could be expected to serve to focus the attention of the weapons system design community, the avionics community, the airframe designers, and those concerned with human factors on system problems now inadequately addressed. In order to take maximum advantage of this coordinated effort and the R&D talent associated with it, the program managers should be collocated with this facility.

The following more specific recommendations are also made by the subgroup:

a. FLIGHT SIMULATOR: In view of the high priority of the Nap of the Earth (NOE) *mission* in the Army's plans and the need for a research flight simulator facility to optimize the helicopter and its associated systems for this mission, an increase in the priority funding of AMRDL plans for building such a research simulator facility is recommended. This facility should be made available no later than 1979, rather than 1981, the target date under the existing plan.

b. RPV PROGRAM: The funding and the schedule for the RPV program were found to be grossly inadequate in relation to the program objectives. The following are the subgroup's recommendations to correct this situation:

(1) Increase/Reprogram funding of Aquila program to insure a sufficiently reliable system and an in-depth test program for the determination of RPV mission effectiveness.

(2) Allow AVSCOM additional time for reliability testing of Acquila system prior to transition to user.

(3) Invite RPV component development programs to address specific critical needs uncovered during initial testing phases of Aquila.

(4) Terminate or transfer to other line elements all development of RPV payloads not in direct support of day or night target acquisition and designation.

c. HUMAN FACTORS: The review of the human factors areas indicates that a unifying structure is needed. It is recommended that such responsibility be assigned.

B. AIR MOBILITY RESEARCH AND DEVELOPMENT LABORATORY (AMRDL)

I. FINDINGS

A. General

The study group spent a major fraction of its time reviewing the AMRDL program in the light of the STOG objectives and the current state-of-the-art helicopter technology.

In general, we found the AMRDL program to be of high quality and well designed to build a technology base for rotary wing aircraft design. The current state-of-the-art is seriously lacking in soundly based quantitative prediction techniques on such elementary matters as the aerodynamic load history on a helicopter rotor blade, with the result that the prediction, during the design process, of such things as stability and control characteristics, vibration levels, acoustic signature, component stress levels, and component fatigue life, is a very low confidence process.

The heavy emphasis in the STOG on improving helicopter survivability in the NOE operational environment, in poor weather, and in a serious threat environment lends great importance to the acquisition of that data base. We found that in each of the STOG areas relatable to helicopter airframe performance prediction and design, good fundamental work was in progress. The 6.2 and 6.3 aerodynamics program of AMRDL is clearly driven by the need to understand (in detail) the basic phenomenology of rotary wing flight and to generate and apply rational design processes to a field still largely dominated by cut-and-try empiricism.

Similarly, in the field of power plants, we found the AMRDL program emphasizing those problems of power plant development whose solution would lead to higher survivability in the Army's operational environment. The emphasis on simplicity, through reduction in numbers of stages in compressors, and on reliability, through development of simpler designs, and on vulnerability reduction, through design simplification and size reduction, seemed to us appropriate and clearly relevant. Considerable leverage has been generated by the collocation of Army and NASA Centers. There appeared to be excellent coupling of the engine program with problems encountered by the user.

In the field of aircraft structures we found a program of development of new composite materials, guided by a keen appreciation of the importance of improving reliability, survivability, and performance in the Army's battlefield environment. The development of fiber reinforced plastic materials for blade structures, fuselage elements, control elements, and transmission components, sponsored by AMRDL, can be expected to yield large dividends in reduced vulnerability. Attention is also being placed on reduced R.F. signatures, and improved payload-to-gross-weight fractions, not only in new designs of rotary wing machines, but also through retrofit and modification programs, in

designs now in the inventory or well along in development for procurement. As examples, low radar cross-section composite rotor blades could substantially reduce the vulnerability of the UH-1 and Cobra machines in inventory, and a composite fuselage could significantly increase the payload of either UTTAS without any sacrifice of other desirable characteristics. Finally, the development of ballistically tolerant structural elements has already contributed substantially to the survivability of the UTTAS and AAH designs, through significant reduction of vulnerable areas of those machines.

In the component area, we noted the benefits of such developments as elastomeric bearings, aimed at increasing survivability by improving reliability, and the increased emphasis on design for zero maintenance.

Thus, in the aggregate, we found the AMRDL aircraft technology programs directly related to the STOG primary objectives and of high quality, relevance, and utility.

In the area of non-systems advanced development (6.3a) we also found many worthwhile programs in progress. These technical demonstrator programs are extremely valuable in complementing, extending, and proving the results of the more basic 6.2 efforts. In addition, by demonstrating the applications of new technology, these programs shorten the time required for new concepts and technology to reach the industry, gain user confidence; and consequently, accelerate their incorporation into new aircraft.

So far we have been discussing the helicopter as a flying machine and the steps that need to be taken to improve its survivability and utility in the combat environment as depicted in the STOG. Without the fundamental understanding that should come from the AMRDL programs, significant advances in the key areas of maneuverability, survivability, reliability, and low operational cost cannot be expected to occur quickly.

In two areas, however, we found what we believe to be a less than satisfactory situation. These are the areas of weapons system design integration and the development of an adequate data base for handling qualities specifications. Weapons system design integration is discussed in a later section.

B. Work of Good Quality in Support of STOG but Inadequately Emphasized

Maneuverability, Handling Qualities: The NOE mission has a high priority in the Army's plans for use of a helicopter. To develop a satisfactory vehicle with the necessary agility, maneuverability and handling qualities will require considerable development effort. Motion based flight simulators have proven to be a most important development facility for this purpose on fixed-wing aircraft. However, existing facilities are deficient in terms of visual presentation and real-time computation of rotor-craft dynamics, and both of these items are necessary for simulation of the NOE task. The AMRDL has a plan which will bring such a facility into use in 1981.

The AMRDL plan for the development of the required simulator capabilities in conjunction with those already existing at the NASA Ames Research Center is considered to be a good plan and a cost-effective approach. However, it is considered to be inadequately emphasized. In view of the importance of the NOE mission in the Army's plans, the availability of this simulator facility should be accelerated.

C. Work of High Quality and High Relevance to Future Army Needs but not in Direct Support of the STOG

AMRDL has two flight demonstrator programs, the ABC and the Tilt Rotor, each of which promises to achieve substantially higher speed than can be attained with conventional helicopters.

a. <u>ABC</u>:

With respect to the ABC, the group had the benefit of a special briefing on the characteristics of the machine by Dr. Carlson. The ABC achieves high speeds through the use of a very high stiffness contrarotating rotor system, which permits unloading the retreating blades while maintaining roll trim. The design eliminates the necessity for a tail rotor, allowing a shorter fuselage. It also, through the high stiffness rotor system the concept demands, has substantially higher roll and pitch agility than conventional helicopters.

The concept may well prove quieter, and may become competitive with conventional machines in payload to gross-weight fraction, although these matters have not been sufficiently explored for definitive resolution. Conventional machines can, in principal be developed with substantially higher control power than existing inventory machines, but much further systems work needs to be done to refine these matters.

Thus, on the whole, we find that it is not yet clear whether the ABC machine can be developed into a strong competitor to conventional helicopters in the low speed, low level NOE environment. The machine, as built, does have high relevance to the Army program if employed as a test vehicle to explore the benefits of high agility in NOE operation.

We recommend that the machine be employed in systematic flight test comparison with machines of more conventional stability and control characteristics in the NOE environment to aid in development of stability and control specifications for NOE operations.

b. TILT ROTOR:

The Tilt Rotor is an exciting development, offering the hover efficiency of the helicopter and high speed cruise efficiencies comparable to fixed wing aircraft. The program, a joint venture with NASA, offers promise of commercial utility, and offers the Army capabilities which cannot be achieved by helicopters or fixed-wing alone.

The most obvious gain over the helicopter is high speed cruise - speeds of over 300 knots seem assured. While the current emphasis on NOE performance has resulted in deemphasis of high speed cruise efficiency, we feel that the program has relevance to future Army needs, and that the program should be supported fully.

Among the operational characteristics that appear potentially important and unique to the concept, we note that the inherently high cruise efficiency could be exploited in the design of self-deployable helicopter gunships, and in the design of surveillance machines as follow-on to the OV-1 Mohawk and the Beech ASA electronic warfare machines which could be operated off unprepared forward area sites and airports with severely cratered runways.

The high speed characteristics could perhaps also be usefully employed for substantially more rapid concentrations of fire-power than is possible with the current concept of armed helicopters.

D. Gaps - Work that Should be Done in Support of STOG but not Being Accomplished

The STOG calls for improving the autorotation capability of helicopters.

The group found that it is technically possible to provide energy storage through high inertia rotor systems, fly wheels, or other means to eliminate the "dead man's curve" in helicopter operations, and to provide greater maneuverability in pop-up maneuvers.

The importance attached to NOE operations for survivability in the battlefield leads us to the conclusion that the emphasis given to attaining this objective is far too small. We recommend initiating a systems study aimed at eliminating the dead man's curve in all inventory and developmental machines as a matter of urgency.

II. RECOMMENDATIONS

Research Flight Simulator:

In view of the high priority of the NOE mission in the Army's plans and the need for a research flight simulator facility to optimize the helicopter and its associated systems for this mission, an increase in the priority and funding of AMRDL plans for building such a research

simulator facility is recommended. This facility should be made available no later than 1979, rather than 1981, the target date under the existing plan.

III. DETAILED STUDY RESULTS AND RATIONALE FOR FINDINGS

Research Flight Simulator:

The special consideration that is recommended for research flight simulators under "Recommendations" is due to the important role that these simulators can play in the development of helicopters with characteristics that are well adapted to the NOE mission. This mission poses a most difficult piloting task with the dynamics and handling qualities typical of present helicopter designs. Furthermore, the task has to be accomplished under highly unfavorable visual conditions, at night, or in smoke or haze. On top of this, it has to be performed while the pilot is also involved with the workload imposed by communications, navigation, reconnaissance and fire control tasks. This combination of circumstances imposes a special premium on the modification of the helicopter's flight dynamics and handling qualities to facilitate the pilot's task. Potentially, it will require significant changes in the helicopter's configuration and flight controls. It is not obvious what these changes should be, and it would be unduly time consuming to conduct flight experiments over the range of likely design parameters. A research flight simulator could cut years off this development process.

The foregoing statements are based to a large extent on fixed-wing experience over the past 20 years. The adjustment of fixed-wing stability and flight control characteristics was changed from a cut and try approach to a quantitative science by the use of special research flight simulators to explain the influence of various aerodynamic parameters on the handling qualities of fixed-wing aircraft. Helicopters, with inherently poor handling characteristics, require the same type of approach now that the NOE mission has placed such a great stress on the pilot.

The need for upgrading the existing special research simulators, which have been adequate for the fixed-wing case, is due to two factors. In the first place the real-time modeling of helicopter dynamics requires representation of a much more complex machine, with much higher frequency characteristics. Present real-time dynamic modeling by way of computers falls far short of the requirements. Thus, the present simulators, which have adequate motion capability, require a much improved capability for real-time dynamic modeling to control the motion of the simulator.

The second factor that requires upgrading for these research simulators is the visual presentation. Peripheral vision characteristics of the present research simulators must be much improved to represent the actual flight situation to the pilot. Furthermore, the visual presentations must simulate visibility conditions encountered at night and in smoke or haze to truly represent a NOE flight task. Eventually there must be superimposed on this pure flying task all the other tasks that a NOE pilot must perform simultaneously.

A research simulator facility for such a purpose will be unique and costly. Its cost and time-to-readiness can be reduced by upgrading existing facilities which have the required motion capabilities at Ames Research Center. AMRDL and Ames have a plan for such upgrading, but due to budget limitations it will not have an operational capability until 1981. The recommendation of this panel is that this upgrading be accelerated with the objective of availability by 1979.

A research simulator facility of this nature would be a national facility in the same sense that the 40 X 80 wind-tunnel at Ames is now. It would be used initially by the AMRDL lab group to obtain a better and more quantifiable understanding of the factors influencing the flyability of a helicopter, particularly in the hovering to 60 mph region which current helicopters are designed merely to "fly-thru." This use in itself would justify it; however, it has the longer term potential which would make it a useful tool for the following applications:

a. It will be of use to the helicopter industry for the design decisions and modifications to new designs to improve their handling qualities, explore flight limits, evaluate benefits due to modifications under study. Precedence has been established in the use of simulators for this purpose for fixed-wing aircraft.

b. Once a specific helicopter is available, it is customary to develop its tactics for NOE use by flight test by CDEC at Hunter-Liggett. This process will be accelerated and made less hazardous if the pilots can make their initial trials by way of a realistic flight simulator. Significant cost and time benefits should be realized by this approach.

c. Much of the basic research use of the simulators would be for the rotor-craft handling characteristics. But as designs matured the simulator could be used for system integration functions. Navigation and flight control subsystems would be added, thus workability as a system determined and pilot workload evaluated. The simulator would become a point of convergence for the aeronautical engineers, pilots, human factors engineers and training command people who have to collaborate in the development of a total system.

d. Other simulators are needed for work in the human factors areas. Generally they can be less complex and require less flexibility than the research simulator facility contemplated by AMRDL. They will be simplified, more-special purpose derivatives of the AMRDL simulator. Thus the facility development work done for the AMRDL simulator will be directly applicable to other more-specialized simulators.

In summary, both the near-term and longer term considerations justify an increased emphasis and funding for the AMRDL simulator to bring it into use as rapidly as feasible.

C. REMOTELY PILOTED VEHICLE (RPV) PROGRAM

I. FINDINGS

A. General

The STOG explicitly states a need for the development of survivable, inexpensive, multipurpose, retrievable and low signature RPV's with secure data links as well as a large variety of special purpose payloads for a wide range of missions. In comparing the present RPV program to the STOG, one concludes that there is an extremely good match. The subgroup, however, questions the desirability of tying the present program to such a broad requirement at this time, since the user has stated he wishes to gain "hands-on" experience with the mini RPV concept before deciding if a requirement is necessary. It is our opinion that, in the near term, the STOG, and the program should concentrate on the specific objective of delivering a reliable mini RPV system to meet the near term objective of the user, thereby maximizing the utility of the demonstration system to TRADOC, and assuring that technical problems, which are specific to Aquila only, do not unduly influence the TRADOC deliberations.

The subgroup concurs with the initiation of a 6.2 line item for RPV's. We particularly encourage development of specific, advanced technologies which will reduce the technical risk of the initial demonstration programs, such as improved actuators, innovative recovery techniques, anti-jam data links, improved engines, and reduced observables.

B. Gaps - Work that Should be Done in Support of STOG but not Being Accomplished

Work should be accomplished to backup critical system component problems. Some activity is going on in many of the areas, however, it is at a relatively low funding level which makes it doubtful that meaningful solutions can be developed in time to affect the demonstration system. Specifically, additional work is needed in improved servos and actuators and retrieval techniques.

II. RECOMMENDATIONS

A. Gaps to be Filled to Support STOG

(1) Increase/reprogram funding of the Aquila/Project SEEKER program to insure a sufficiently reliable system and an in-depth test program for the determination of RPV mission effectiveness.

(2) Allow AVSCOM additional time for reliability testing of the Aquila System prior to transition to the user. Provide the user with complementary capability for the evaluation of the system which will enhance the test data base (see new initiatives).

(3) Initiate RPV component development programs to address specific critical needs uncovered during the intial testing phases of Aquila.

B. Work to be Terminated

Terminate or transfer to other line elements all development of RPV payloads not in direct support of the present demonstration objective of day or night target acquisition and designation.

C. Significant Comments for STOG 78

Reduce the scope of the STOG elements to concentrate on the objectives clearly set forth in the LOA until a ROC is initiated or the concept is rejected.

D. New Initiatives

There is concern that the Aquila program will not be sufficiently reliable at this point in its development to allow TRADOC an adequate number of successful missions to realistically assess the tactical utility of the mini RPV concept. Plans are presently underway to increase RPV sensor evaluation time by flying the sensors aboard a manned platform. We concur in this task but believe one should go further and control both the manned platform and sensors through the RPV ground control system. To the ground controller, such an arrangement would appear identical to the RPV system, allowing a significant number of tests to be accomplished at no risk to the vehicles and sensor payloads available to the program.

III. DETAILED STUDY RESULTS AND RATIONALE FOR FINDINGS

As discussed in the findings, we found all the RPV activity in direct support of STOG objectives. Time did not permit an exhaustive review of the technical quality of the projects; however, we were impressed with the scope of the tasks underway and the accomplishment to date. A program of this kind is unique in that an RPV may have very good overall reliability; yet one minor equipment problem can result in destruction of the vehicle, as has occurred in a number of instances thus far. The primary element of the program is Aquila, which in our opinion is an extremely ambitious undertaking inadequately funded and on a schedule too short to have a high probability of meeting the TRADOC need to have "hands-on" experience with a demonstrator system. When the program was initially formulated, the technology appeared to be a simple extension of the radio controlled model plane art. ARPA has a reasonable experience flying and demonstrating systems, however, the systems were operated by experienced "modelers" and take-off and recovery was made on runways. It appeared to be a simple task to add the additional sophistication of zero length launch and retrieval and near automatic flight; however, once designed, one finds these changes add significant complexity. The system has been designed only to utilize the operator for command functions, leaving other aspects of the system to computers and sensors. There are provisions for manual override; however, the crucial steps, such as landing, require that many of the automatic systems operate.

We concur that such automatic flying is a necessity for field use, and believe that all the functions can be made to work reliably and at low cost. We also believe that many of the failures to date have been caused by components and software, infant mortality, and procedures during the complicated sequence of events required. This has been further aggravated by the extremely short time and financial constraints which have led to engineering "shortcuts" and lack of ground testing. It is our belief that additional time and money will be required to develop the Aquila system to a sufficiently reliable state such that statistically meaningful user results will be obtained.

We believe that STOG-78 objectives should be restricted until a ROC decision is made. Under these conditions, several advanced payload concepts such as communication jammers, millimeter target detection radar, etc., should be delayed or funded elsewhere in the Army or ARPA.

D. HUMAN FACTORS/BEHAVIORAL SCIENCES

I. FINDINGS

A. General

The work in this area is being covered by four agencies of the Army with inadequate coordination of efforts between organizations. The STOG objectives relevant to human factors are covered, but fundamental gaps of a serious nature exist which influence all aviation oriented man/machine interface problems. The work being done is generally of good to excellent quality with a few exceptions.

B. Work of Good Quality in Support of STOG but Inadequately Emphasized

(1) The Human Engineering Laboratory covers the problems of instrument dials for most rapid transfer of information, control system/human operator design, and cockpit lighting. These areas are inadequately emphasized as indicated by the level of support and time allocated. It is felt that incomplete or limited studies, while good in part, are not appropriate if not done to the depth professionally required.

(2) The work of USAARL in the establishment of pilot-copilot/navigator workload and physiologic and psychologic performance technology data base under combined stress (noise, vibration, thermal extremes, fatigue, and NOE under night/adverse weather conditions) is of good quality in support of the STOG. This work utilizes the combination of a training flight simulator and a programable computer for control as well as in-flight experiments. Increased emphasis is imperative to insure that an adequate and functional human performance technology data base is established to futher the STOG objectives of reduced pilot workload and an improved man/machine interface. Budgetary and manpower constraints have severely hampered these efforts.

(3) Good quality work by USAARL in support of the STOG encompasses the special sensory requirements, i.e., visual, aural, integrative, and proprioceptive for rotary wing aircrews to meet operational demands in combat. Visual and aural needs represent a major portion of the rotary wing aviator sensory input in the flight environment. Inadequate emphasis by budgetary and personnel constraints have delayed efforts in this critical area.

(4) The STOG emphasizes the need for improved life support equipment for aircrews. The work of USAARL through the establishment of the Life Support Equipment Retrieval Program (AR 95-5) provides the necessary data base upon which to evaluate future technology. This effort is considered of good quality in support of the STOG. Increased emphasis is required in the overall integration of personal life support equipment with the aircraft life support systems and mission essential equipment (night vision devices, navigational displays, weapons delivery devices, and on-board survival equipment).

(5) The efforts outlined by ARI to obtain education and transfer characteristics and to reduce training time by use of simulators and trainers has a very large payoff and should be continued. The research is presently being accomplished without the benefit of a dedicated training research simulator. The development of this research tool should be accelerated. This thrust would provide Army-wide training effectiveness and cost benefits through the development of improved flight training methodologies, structured training, aviator performance assessment, and aviator selection. The required device is modest, in that it requires a UH-1 flight simulator crew station and motion base with a general purpose computer. The aviation training research program in progress is considered to be of good quality but the low priority placed upon the acquisition of a training research simulator will result in future deficiencies in meeting projected training research requirements.

(6) STOG objective 77-7.15 cannot be met without increased emphasis in the development of the flight research simulator fully capable of studying the effects of motion base and visuals. This can be done with full research simulators as described by AMRDL in the section pertaining to that subject. The research program should be coordinated with ARI for the training and educational aspects and with USAARL for the human factor questions.

C. Gaps - Work that Should be Done in Support of STOG but not Being Accomplished

The workload of the air crew - pilot/copilot/weapon system operator/ navigator, in NOE conditions, especially during night/adverse weather operations will saturate the individual capabilities at a level far below that performance required for successful task completion. The fundamental human factors technology base has not been established for rotary wing operations. Under the rapidly increasing demands related to planned tactical employment of aviation assets, the human operator must be capable of processing ever increasing amounts of information and data, select courses of action, evaluate the probability of success or failure, and manipulate controls or cause motion.

The establishment of the fundamental data base of the human operator in the helicopter, rotary wing system has not been accomplished. The response to various psychosensory inputs and the resultant psychomotor skill outputs must be documented in order that the air vehicle may be designed/redesigned to maximize the effectiveness of the pilot/copilot navigator in the total system context. The lack of these data prevents the adequate definition of the aviation weapon system requirements as they relate to the individual.

Within the vacuum defined above, remedial efforts have been attempted in many areas as a method of compensation to meet short term goals.

Within the large gap thus defined the following areas need attention on an integrated nonfragmented basis:

a. Visual oculomotor skills must be defined in the broad context of employment of the aircraft weapon system.

b. Vestibular-auditory contribution to air crew performance in the dynamics of actual and simulated flight is required.

c. The proprioceptive-kinesthetic data base is fragmented and requires consolidation for appropriate application to crew station design and flight controls.

d. The aviation physiological and psychological effects of combined stress during rotary wing operation in future operational employment must be established.

As an example of one area needing attention and a cohesive effort, psychomotor and psychosensory proprioceptive studies involving long duration flights and sustained around the clock operations are being conducted to a limited degree by the USA Aeromedical Research Laboratory (USAARL). Navigator oculomotor studies for performance in NOE tasks are also being conducted by the same group. These efforts should be expanded to obtain base line data to describe the relation of cue and action required to fly rotary wing aircraft. The outcome expected would be definition of instrumentation needs, visibility requirements, and control characteristics.

e. Three successive programs, originating in the Navy, recognized the lack of a coordinated, comprehensive systems approach to the difficult problem of the human operator in a helicopter. The Integrated, Man-Helicopter Engineering Program (IM-HEP), the Army Navy Instrumentation Program (ANIP) and finally, the Joint Army Navy Aircraft Instrumentation Research (JANAIR) were the efforts beginning in 1957 and lasting for a subsequent ten years. There seems to be no current effort either within the Services or within the Army to bring these areas together or to develop a concerted effort to obtain the base line data. The work to date stems primarily from extrapolation of fixed-wing technology. To produce the vast reductions in workload demanded by NOE flight, even limited to clear day, the definition of oculomotor and proprioceptive responses is needed. The work should be integrated as a whole, bringing to bear at least the four Army agencies now involved.

f. The review of the current "fielded systems" disclosed that there was little continuing direct participation on the part of the human factors/aviation medicine community in design/redesign of Army aircraft. That which has occurred has been hurried, limited and fractional. Most attention has been paid to the mechanical technologies involved rather than the human interface.

g. The life support efforts are fragmented. Parts of the task are being accomplished by several agencies with no apparent aircraft systems integration.

II. RECOMMENDATIONS

A. Gaps to be Filled to Support STOG

1. While the broad umbrella of technology definition of the STOG 77 covers the above areas, it is felt that positive action is required to fill the voids created by the extremely fragmented and non-integrated efforts. It is recommended that the Department of the Army, at the earliest possible time, assign to AVSCOM, as the responsible agency for aviation systems, the requirement to develop a coordinated, comprehensive human factors program as it relates to Army aviation. AVSCOM should be directed to fully utilize the capabilities and expertise which exist in the USAARL, HEL, ARI and AMRDL in this program and not develop new, duplicative capabilities. Specifically, the following areas of expertise exist:

a. USAARL to develop the technical base of human operator response data to oculomotor, visual, auditory and other psychosensory inputs.

b. HEL to develop the dials, switches, etc., to optimize the human response capabilities as indicated by the data base derived from a, above.

c. USAMRDL to develop the air vehicle which accommodates the human operator characteristics, instrumentation and controls based upon a and b above.

d. USARI to develop the appropriate data base, equipment and systems to provide training and doctrine to optimize the learning function of new air crews in the systems developed as a result of c, above.

2. Further, the development of an integrating agency is needed. Therefore, the former Joint Army Navy Aircraft Instrumentation Research Committee should be reformed and chartered as a Triservice committee. The US Army (USAARL) should be designated as the executive agent, since the Army has the responsibility for all rotary wing training. This is to assure coordinated efforts toward obtaining the fundamental data base as applied to rotary wing aircraft. If the other Services do not wish to participate, then an all Army effort must be initiated.

3. The systems review and discussions indicated that the human factors/aviation medicine community has to have an input into the aircraft weapon system. Furthermore, their expertise should be a required input throughout the aviation program.

4. The life support systems integration for US Army Aviation must have central direction and adequate emphasis.

B. Work to be Terminated

With the implementation of the activity and task delineation of A above, there are no items for consideration under this title.

C. Significant Comments for STOG 78

1. The STOG 77 does not specifically address the human factors problems associated with the sustained or long duration flight requirement under the operational concept of day/night NOE and combined arms tactics. This should be emphasized since it adds considerably to the stress/fatigue level of air and ground crews, probably reducing their combat capability significantly.

2. The STOG 77 refers to night/adverse weather operations. It is suggested that the target or operational area obscuration can be created by either friend or foe and should be considered heavily in systems design and human functional capability. Specifically, smoke or man created fog will be a very serious deterrent to operational capabilities.

III. DETAILED STUDY RESULTS AND RATIONALE FOR FINDINGS

Detailed review of the programs conducted in support of the human factor/aviation medicine requirements of proposed Army aviation employment in the time frame covered by the STOG indicated good quality work. The overall effort is, however, directed toward fragmented portions of technological and operational problem areas.

The USAARL is engaged in human performance measurements of aircrew under intensive combined stresses found in the rotary wing aircraft environment. The data obtained provides the initial technology base required to maximize performance and optimize the machine man interface in operationally employed aircraft. This agency is a medical research facility under the control of the US Army Medical Research and Development Command under the Surgeon General. The interaction of USAARL with AVSCOM, AMRDL and HEL is fragmented and illdefined. The emphasis of USAARL is THE MAN in the aircraft from a physiological and psychological performance base and integration of THE MAN into the total weapons system. USAARL is not included in the early aircraft weapons systems development cycle to insure appropriate human factor/aviation medical input prior to the need for "band aid" fix of a medically unacceptable system.

It is apparent from the stated requirements of the user in GEN DePuy's "W.P.T." formula that maximum efficiency must be obtained from the training program. The requirements coupled with the increasing costs of operating the aircraft equipment are the driving force which dictates the necessity to increase the utilization of simulation for training. The Synthetic Flight Training System (SFTS) addresses the procurement of the simulation hardware but does not consider the extent to which flight

simulation can be used nor its method of employment. Therefore, it is necessary to obtain a supporting training research simulator which can be used to study the many facets involved in the employment of simulation in Army wide flight training programs.

The human operator interface with the helicopter has generally been treated as a direct extrapolation from fixed wing experience. Instruments were transferred directly, controls were created in a similar fashion, techniques of flight operation were copied. There are significant differences as exemplified by the pilot workload. Experiments indicate that the operator of a helicopter must scan his instruments five times as frequently as an operator of a fixed wing aircraft.

The fundamental relationships between cues and required action needs to be established. Only fragmented results are available as of this date. Examples of efforts leading towards a comprehensive approach are found in programs such as the Integrated Man-Helicopter Engineering Program, the Army-Navy Instrumentation Program, and the Joint Army Navy Aircraft Instrumentation Research Program.

The four organizations of the Army involved (USAARL, HEL, USAMRDL, and USARI) have no centrally focused efforts in the aviation human factors area as indicated by the briefings and material submitted. The AVSCOM has central responsiblity for the air vehicle/weapon system and therefore, should be responsible for this vital area and tasked by DA to coordinate those diffuse projects.

E. HELICOPTER WEAPONS SYSTEM DESIGN INTEGRATION

I. FINDINGS

A. Gaps - Work that Should be Done in Support of STOG but not Being Accomplished

The STOG clearly identifies a high priority requirement for weapons delivery from helicopters. Specifically, the STOG objectives include the development of true fire-and-forget weapons systems for use against enemy air defense weapons expected to be used against helicopters. Realization of this capability will require a helicopter-avionics-weapons integrated system approach. Review of the ECOM laboratory plan indicates that electronics subsystems are being developed to support this weapons requirement. Also, discussions with other summer study members indicate that MICOM is working such essential missile system elements as seekers, DME, tactical software, optical guidance, etc. We also understand that Frankford Arsenal is engaged in similar kinds of activities. The AMRDL has a good, solid program in support of this requirement, but it is concentrated on the helicopter as a flying machine, not on the helicopter weapon system. The systems definition, systems requirements and the preliminary design of a weapons system from the mission requirements down is not being addressed, and it appears that none of the involved organizations believes that he has the lead in this function. The fire-and-forget weapons system is an example of the above description--the elements and pieces of the problem appear to be coming along well, the "black boxes" will be completed and available, but no one is looking after the system, and there can be little assurance that the elements will form a system that will play well, if at all, when pulled together in a helicopter. This approach can only result in a weapons system that will be costly, will require many fixes and band aids, and will probably be compromised on overall performance.

Development of an effective aviation weapons system to meet the stated requirement must early address the overall mission and system requirements and then the integration of the necessary avionics, the weapons complement and the helicopter platform. This will include integration of the communication, navigation, and fire control subsystems (including displays) with the helicopter and all other electrical and electromagnetic subsystems in a non-interfering manner.

The subgroup concluded that substantial progress toward weapons system integration can best be assured by establishing a center of competence, with appropriate facilities, personnel, and responsibility, by:

a. Bringing the program managers for major helicopter systems into closer relation with the research capabilities. Moving these program managers to AMRDL should facilitate the program manager's use of the R&D talent already present and assure "real world" problems being incorporated into the tech base program.

b. Providing a real-time research flight simulator capability at AMRDL as a matter of urgency. Substantial progress on understanding the handling qualities of helicopters can be expected, with the facility serving as a focal point to bring together the people who can contribute: pilots, design engineers, human factors experts and the user.

c. Providing a weapons system integration facility at AMRDL in which all subsystems can be interconnected to uncover, in the laboratory, the subsystem interference and interactive effects that would otherwise be found in flight late in the development programs. The facility could be expected to serve to focus the attention of the weapon system design community, the avionics community, and the airframe designers, on the system problems now inadequately addressed and through its employment by members of those communities, automatically bring the several, fragmented efforts into a coherent whole.

II. RECOMMENDATIONS

A. Gaps to be Filled in Support of STOG

1. AVSCOM initiate action to designate responsibility for helicopter weapons system design and integration.

2. AVSCOM collocate helicopter program managers with AMRDL.

B. New Initiatives

1. AMRDL establish a weapons system integration laboratory which approaches the helicopter as a total weapons system.

C. Significant Comments for STOG 78

1. Since the advance of technology and development is so great, it is recommended that a new mechanism for bringing user and developer together on a regular periodic basis at the working level be initiated. To assure that the concept has proper emphasis, supervision and review at top command level is further recommended.

2. Since there are fundamentally two sources of recommendations for changes in systems, and each tends to fall into one of two categories, it is recommended that the STOG-78 be separated by item and assigned priority in that category. These are:

   a. Evolutionary changes.

   b. Revolutionary changes.

III. DETAILED STUDY RESULTS AND RATIONALE FOR FINDINGS

The sources for changes in weapons and systems usually come from either the user or the developer. These have fundamental differences due to the perspective of the person recommending the change. The user tends to suggest modifications to existing systems which are evolutionary in nature and also, are normally short-term in the response times required to bring into being. The developer generally provides suggested alterations to weapon systems which are revolutionary and, in most cases, require long lead times to bring the concept into being. The cross between the two sources, user and developer, is an absolute must since the user may have no background to perceive what can be done with the new technology to improve present systems or new developments. At the same time, the developer may have no capability to understand the tactical employment. As an example, during the briefings it was represented that there was no desire by the user for an autopilot on rotary wing aircraft. In the context of NOE at night or in adverse weather, the improvement in stability and control of the helicopter is virtually mandatory to relieve the workload associated with simple vehicle control. This would then permit the operator time to accomplish part of other phases of his task.

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The Army Scientific Advisory Panel (ASAP) conducted Summer Study '76 at the Armed Forces Staff College, Norfolk, VA, during the period 19-30 July 1976. The Panel examined the compatibility of the Science and Technology Objectives Guide (STOG), which delineates desired operational capabilities, and the system development plans of the various Army Laboratories to determine if the laboratory programs include the appropriate technology efforts to achieve the desired systems capabilities. The Panel made the examination through the efforts of the six Subgroups of Armament, Aviation, Electronics, Missiles, Mobility, and

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